

## A new species of *Simulium* (*Nevermannia*) (Diptera: Simuliidae) from Hokkaido, Japan

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**Abstract:** *Simulium* (*Nevermannia*) *babai* sp. nov. is described on the basis of the reared adult females, males, pupae and mature larvae collected from Hokkaido, Japan. This new species belongs to the *vernum* species-group and is very similar to *S. (N.) uemotoi* Sato, Takaoka and Fukuda in having the yellowish femora and tibiae but is distinguished from the latter species by the medium-sized female sensory vesicle, the smaller number of the male large eye-facets, and the round medium-sized postgenal cleft of the larva. In a supplemental note, *S. (N.) subcostatum chejuense* Takaoka, a member of the *vernum* species-group, is raised to a full species.

Key words: *Nevermannia*, Simuliidae, *Simulium*, black fly, *vernum* species-group, Japan

The *vernum* species-group of the sub-genus *Simulium* (*Nevermannia*) is for the most part distributed in the Holarctic Region (Adler et al., 2004), and is one of the dominant groups in Japan consisting of 12 (16.7%) of the 72 simuliid species reported from Japan (Sato et al., 2004, 2005; Takaoka and Saito, 2007a). Recently we found two undescribed species of the *vernum* species-group, one from Ibaraki Prefecture, Honshu, and the other from Hokkaido, of which the former was already described as a new species by Takaoka and Saito (2007b). In this paper, the latter species will be described new to science on the basis of the female, male, pupal and larval specimens collected from Otaru, Hokkaido, Japan. The female and male adults of this new species are characterized by the leg color, i.e., both the femora and tibiae are mostly yellowish while the tarsi are medium brown to black, by which it is readily distinguished from most of the known member species in Japan and other countries.

The terms for morphological features

used here follow those of Takaoka (2003). Holotype and paratype specimens of the new species are deposited at the Department of Infectious Disease Control, Faculty of Medicine, Oita University, Oita, Japan.

### *Simulium* (*Nevermannia*) *babai* sp. nov.

**DESCRIPTION. Female.** Body length 2.2–2.5 mm. **Head.** Slightly narrower than width of thorax. Frons brownish-black, thinly whitish-gray pruinose, not shiny, densely covered with yellow recumbent short hairs; frontal ratio 1.86 : 1.00 : 2.26. Frons-head ratio 1.00 : 4.86. Fronto-ocular area (Fig. 1A) directed laterally and somewhat upwardly, deep, rounded apically. Clypeus brownish-black, thinly whitish-gray pruinose, not shiny, moderately covered with yellow short and long hairs. Labrum 0.62 times as long as clypeus. Antenna composed of scape, pedicel, and 9 flagellomeres, medium to dark brown except scape, pedicel, and basal 2/5 of 1st flagellomere yellow. Maxillary palp composed of 5 segments, light to medium brown except segments 1 and 2 ochreous, proportional lengths of 3rd, 4th, and

5th segments 1.00:0.98:2.26; sensory vesicle (Fig. 1B) moderately enlarged, ellipsoidal, 0.38 times as long as 3rd segment, and with medium-sized opening medially. Maxillary lacinia with 11–13 inner and 12 or 13 outer teeth. Mandible with 25 inner and 11 outer teeth. Cibarium (Fig. 1C) smooth. **Thorax.** Scutum dark brown to brownish-black except anterolateral calli ochreous, thinly gray pruinose, shiny at certain angle of light, densely covered with whitish-yellow recumbent short hairs interspersed with whitish-yellow long upright hairs on prescutellar area. Scutellum light brown, covered with whitish-yellow short and long hairs. Postnotum dark brown, gray pruinose, slightly shiny at certain angle of light, bare. Pleural membrane bare. Katepisternum dark brown, longer than deep, shiny, with 1 fine hair on right side in 2 of 6 females examined. **Legs.** Foreleg (Fig. 1D): coxa, trochanter and femur yellow except apical cap of femur grayish; tibia yellowish-white except apical 1/4 brownish-black; tarsus brownish-black; basitarsus somewhat dilated, 6.2 times as long as its greatest width. Midleg (Fig. 1E): coxa medium brown except posterolateral surface brownish-black; trochanter yellow with part of posterior surface light brown; femur yellow except apical tip medium brown; tibia yellow except apical 1/4 brownish-black to black; tarsus black. Hind leg (Fig. 1F): coxa medium brown; trochanter and femur yellow except apical cap of femur medium brown; tibia yellow except apical cap brownish-black; tarsus medium to dark brown; basitarsus (Fig. 1F) slender, nearly parallel-sided, 5.81 times as long as wide, and 0.80 and 0.70 times as wide as tibia and femur, respectively; calcipala (Fig. 1G) well developed, 0.93 times as long as basal width; pedisulcus (Fig. 1G) moderately developed. All claws (Fig. 1H) each with large basal tooth 0.53 times as long as claw. **Wing.** Length 2.2–2.4 mm. Costa with dark spinules and hairs except basal portion with patch of yellow hairs. Subcosta with dark hairs except near apex bare. Hair tuft on stem vein golden yellow. Basal portion of radial vein fully haired.  $R_1$  with dark spinules and hairs.  $R_2$  with dark hairs only. Basal cell and basal median cell absent. **Abdomen.** Basal scale light ochreous, with fringe of yellow long hairs; abdomen light reddish-brown except segment 2 whitish-yellow, tergite of segments 3–5 yellow, and cercus brownish-black; all seg-

ments sparsely to moderately covered with whitish-yellow short hairs, interspersed with dark brown short to medium-long hairs dorsally and dorsolaterally on posterior segments; tergites 6–8 shiny when illuminated at certain angle of light; segment 7 with large sternal plate medially. **Genitalia.** Sternite 8 (Fig. 1I) bare medially, and with 11–23 short to long hairs on each side. Ovipositor valves (Fig. 1I) roughly triangular, rounded medio-posteriorly, thin, membranous, densely covered with microsetae interspersed with 6–9 short fine setae; inner margin moderately sclerotized and narrowly darkened. Genital fork (Fig. 1J) of usual inverted-Y-form, stem slender and well sclerotized; arms of moderate width, strongly folded apically, with wide unsclerotized projection directed medioposteriorly, then appearing irregularly broken. Paraproct in ventral view (Fig. 1K) narrowly bare and darkened along anterior margin, and with 6–9 sensilla on anteromedial surface; paraproct in lateral view (Fig. 1L) slightly produced ventrally beyond ventral margin of cercus, with ventral margin notched medially, and covered with about 20 short to medium-long hairs on ventral and lateral surface. Cercus in ventral view (Fig. 1K) slightly shorter than paraproct, and strongly curved inwardly; cercus in lateral view (Fig. 1L) round or triangular with round apex, about 0.8 times as long as its basal width, and with numerous dark medium-long to long hairs. Spermatheca (Fig. 1M) small, nearly globular, well sclerotized except small area at juncture with duct, with reticulate surface patterns; internal setae absent; both accessory ducts subequal in diameter to each other, and slightly larger in diameter than main duct.

**Male.** Body length 2.5 mm. **Head.** Nearly as wide as thorax. Upper large eye bright vermilion, consisting of 12 vertical columns and 15 horizontal rows of large facets. Face brownish-black, gray pruinose. Clypeus brownish-black, gray pruinose, moderately covered with yellow long hairs. Antenna composed of scape, pedicel and 9 flagellomeres, dark brown except scape, pedicel, and base of 1st flagellomere dull yellow; 1st flagellomere somewhat elongate, 1.82 times as long as 2nd one. Maxillary palp composed of 5 segments, light to medium brown, proportional lengths of 3rd, 4th, and 5th segments 1.00:0.99:2.21; sensory vesicle (Fig. 2A) small, ellipsoidal, 0.17 times as long as

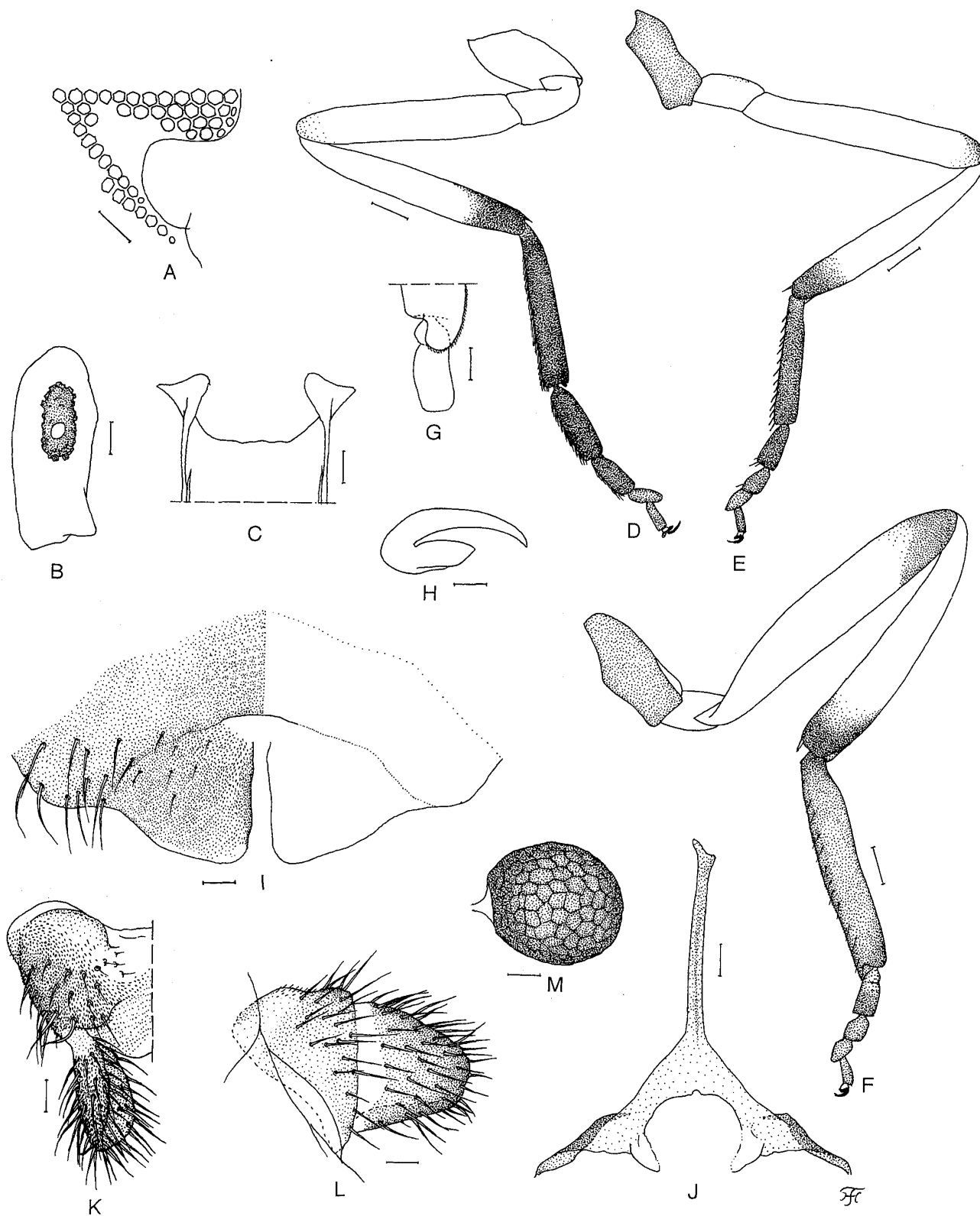
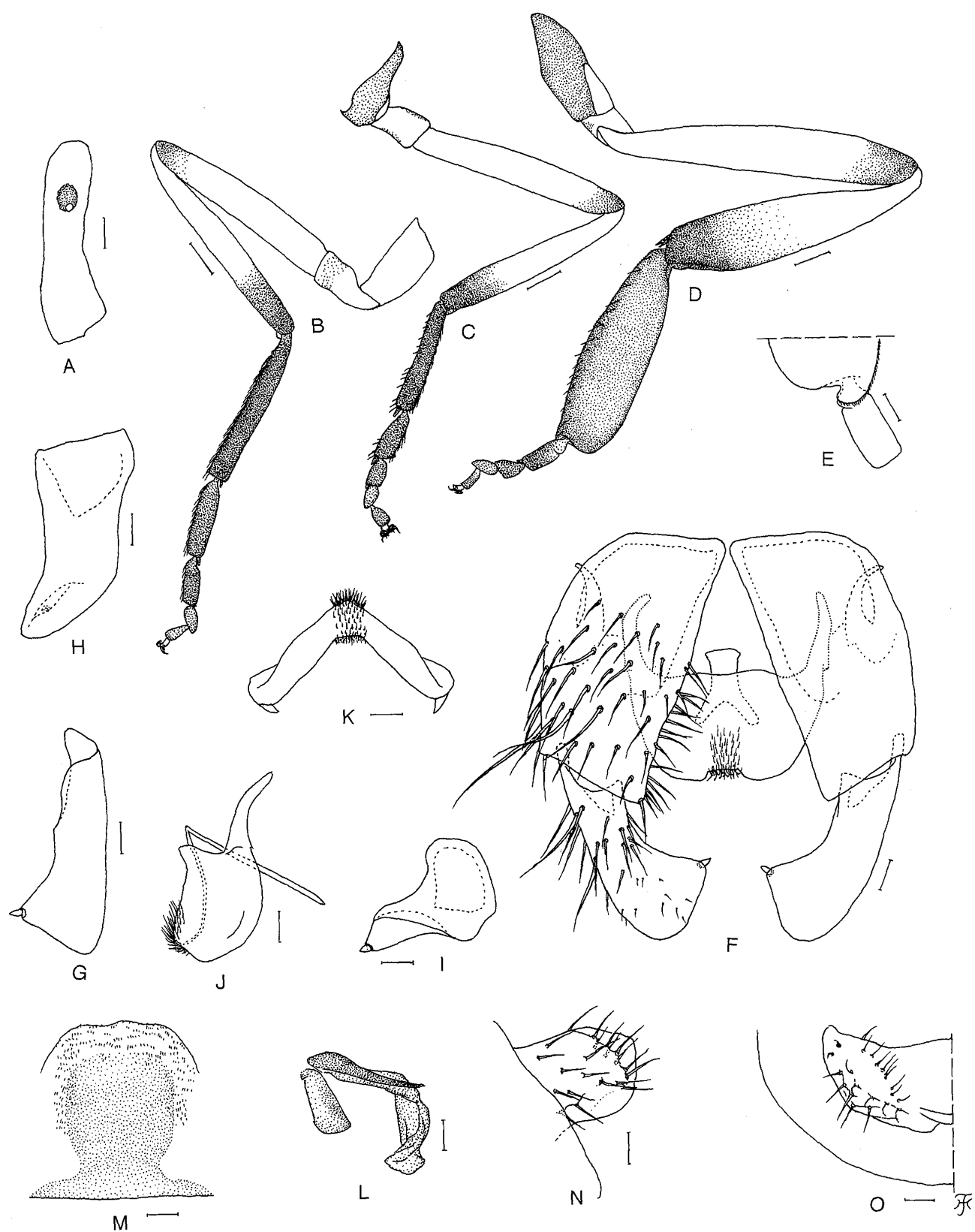


Fig. 1. Female of *Simulium* (*Nevermannia*) *babai* sp. nov. A, fronto-ocular area (right side); B, 3rd maxillary palpal segment (right side, front view); C, cibarium; D, foreleg (left side, anterior view); E, midleg (left side, outer view); F, hind leg (left side, outer view); G, apical part of basitarsus and 2nd tarsal segment of hind leg showing calcipala and pedisulcus (left side, inner view); H, claw; I, 8th sternite and ovipositor valves *in situ* (ventral view); J, genital fork (ventral view); K and L, paraprocts and cerci (right side; K, ventral view; L, lateral view); M, spermatheca (lateral view). Scale bars. 0.1 mm for D-F; 0.04 mm for A and G; 0.02 mm for B, C and I-M; 0.01 mm for H.

3rd segment, with very small opening. **Thorax.** Scutum dark brown to brownish-black, gray pruinose and widely shiny along lateral margins and on prescutellar area when illuminated at certain angle of light, densely covered with yellow short recumbent hairs interspersed with yellow long upright hairs on prescutellar area. Scutellum light yellowish-brown, with yellow short and long hairs. Postnotum brownish-black, bare. Pleural membrane and katapisternum as in female except katapisternum bare in 2 of 3 males examined. **Legs.** Foreleg (Fig. 2B): coxa yellow; trochanter light brown except basal 1/2 yellow on posterior surface, but mostly yellow on anterior surface; femur yellow except apical cap light to medium brown; tibia yellowish-white except apical 1/3 brownish-black; tarsus brownish-black to black; basitarsus cylindrical, 7.47 times as long as its greatest width. Midleg (Fig. 2C): coxa medium brown except posterolateral surface brownish-black; trochanter light to medium brown except base yellow on posterior surface but mostly yellow on anterior surface; femur yellow except apical cap medium brown; tibia yellow except apical 1/4 brownish-black; tarsus brownish-black to black. Hind leg (Fig. 2D): coxa medium to dark brown; trochanter yellow except small area on anterior surface light brown; femur yellow except apical cap medium brown; tibia yellow on basal 1/2 or a little more, then gradually darkened toward apex, and with apical cap brownish-black; tarsus medium to dark brown; basitarsus (Fig. 2D) enlarged, spindle-shaped, 3.31 times as long as its greatest width, and 1.09 and 1.38 times as wide as greatest width of hind tibia and femur, respectively; calcipala (Fig. 2E) well developed, short, about 0.7 times as long as its basal width; pedisulcus (Fig. 2E) well developed. **Wing.** As in female except length 2.0–2.1 mm and subcosta bare. **Abdomen.** Basal scale medium to dark brown, with fringe of yellow long hairs. Dorsal surface of abdominal seg-

ments medium brown to brownish-black, moderately covered with yellow short to long hairs intermixed with dark brown short to medium-long hairs on posterior segments (most of hairs on abdomen light to dark brown in 1 of 3 males); segments 7–9 each with pair of shiny lateral spots when illuminated at certain angle of light; ventral surface of segment 2 pale yellow, those of segments 3 and 4 light brown, and those of other segments medium brown; all sternites shiny when viewed at certain angle of light. **Genitalia.** Coxite in ventral view (Fig. 2F) rectangular, about twice as long as wide. Style in medial view (Fig. 2G) boot-shaped, with inwardly directed triangular flange with small spine at its apex; style in ventrolateral view (Fig. 2H) broad basally, slightly narrowed toward apical 2/5, then abruptly tapered toward apex, about 2.3 times as long as its basal width, and about 0.8 times as long as coxite; style in end view (Fig. 2I) with inwardly directed flange depressed dorsally and ventrally, and tapered toward apex. Ventral plate in ventral view (Fig. 2F) transverse, plate-like, moderately tapered posteriorly, 1.7 times as wide as long, narrowly darkened along anterior margin, with anterior and posterior margins shallowly and markedly notched medially, respectively, and setose medially on posterior 2/5 of ventral surface; arms well sclerotized, slender, and with apical 1/2 slightly or moderately curved inwardly; ventral plate in lateral view (Fig. 2J) with anteroventral margin somewhat produced ventrally, and with arm slightly tapered toward apex, and moderately curved dorsally; ventral plate in end view (Fig. 2K) inverted-V-shaped, and setose medially on posterior surface and also on dorsal surface. Median sclerite in ventral and lateral views (Fig. 2F, J) arising just before anterior margin of ventral plate, and narrow, nearly parallel-sided, and forked apically. Paramere in end view (Fig. 2L) narrow, with 1 long parameral hook directed laterally, and

Fig. 2. Male of *Simulium (Nevermannia) babai* sp. nov. A, 3rd maxillary palpal segment with sensory vesicle (right side, front view); B, foreleg (left side, anterior view); C, midleg (left side, outer view); D, hind leg (left side, outer view); E, apical part of basitarsus and 2nd tarsal segment of hind leg showing calcipala and pedisulcus (left side, inner view); F, coxites, styles, ventral plate and median sclerite *in situ* (ventral view); G, H and I, style (left side; G, medial view; H, ventrolateral view; I, end view); J, ventral plate and median sclerite (lateral view); K, ventral plate (end view); L, paramere (left side, end view); M, aedeagal membrane and dorsal plate (posterodorsal view); N and O, 10th abdominal segment and cercus (right side; N, lateral view; O, end view). Scale bars. 0.1 mm for B–D; 0.04 mm for E; 0.02 mm for A and F–O.



with small isolated sclerotized plate near base of hook. Aedeagal membrane (Fig. 2M) sparsely covered with microsetae, and dorsal plate in posterodorsal view (Fig. 2M) moderately sclerotized, inverted-T-shaped, wide, with lateral margins deeply concave near base. Abdominal segment 10 in lateral view (Fig. 2N) with 3–5 hairs on each side. Cercus in lateral view (Fig. 2N) slightly produced posteriorly, with about 18 hairs; cercus in end view (Fig. 2O) narrow obliquely.

**Pupa.** Body length (excluding gill filaments) about 2.5 mm. **Head.** Integument (Fig. 3A, C) yellow to yellowish-brown, usually very sparsely (though rather moderately in 2 female pupal exuviae, Fig. 3B) covered with round tubercles on frons and part of face, and on narrow area along each posterodorsal margin; antennal sheath almost bare; frons (Fig. 3A) with 3 simple very long trichomes on each side; face (Fig. 3A) with 1 very long simple trichome on each side. **Thorax.** Integument almost bare on anterodorsal surface, but sparsely to moderately covered with round tubercles on other surfaces, and with 3 very long simple trichomes mediodorsally, 2 simple trichomes (1 very long and 1 long) anterolaterally, 1 long simple trichome posterolaterally, and 3 simple trichomes (1 long, 2 medium-long) ventrolaterally, on each side. Gill (Fig. 3D, E) with 4 slender thread-like filaments, longer than pupal body, arranged vertically in dorsal and ventral pairs arising from short common basal stalk; common basal stalk slightly thicker than interspiracular trunk, and with transparent swollen portion ventrally; stalk of ventral pair as thick as that of dorsal pair, but usually longer than that of dorsal pair, and subequal in length to, or shorter than, common basal stalk; all filaments subequal in length (2.5–3.0 mm including common basal stalk), dark gray to light brown, directed forwards, gradually tapered toward apex, furnished with distinct annular ridges and furrows, and densely covered with minute tubercles on outer surface.

**Abdomen.** Dorsally, segments 1 and 9 weakly sclerotized and light yellowish-brown, other segments yellowish at least anterior area or around spine-combs; segments 1 and 2 moderately covered with small tubercles; segment 1 with 1 long slender simple seta on each side; segment 2 with 1 long slender simple seta and 5 short spinous setae on each side; segments 3 and 4, each with 4 dark stout hooks and 1 short spinous seta on each side; segments 5–8 each with spine-combs and comb-like groups of minute spines lying transversely along anterior margin on each side; segment 9 with pair of cone-shaped terminal hooks (Fig. 3F), and comb-like groups of minute spines. Ventrally, segments 3–8 nearly transparent, segment 9 weakly sclerotized and yellow; segment 4 with 1 dark simple hooklet (slightly shorter and smaller than those on segments 5–7) and 3 short simple setae on each side; segment 5 with 2 dark bifid hooks and a few short simple setae on each side; segments 6 and 7 each with 1 dark bifid inner hook and 1 dark simple outer hook, and a few short simple setae on each side; segments 4–8 with comb-like groups of minute spines. Segment 9 with 2 short simple setae on each lateral side. **Cocoon** (Fig. 3 G, H). Simple, wall-pocket-shaped, neatly woven, thin except anterior margin thickly woven, and extending ventrolaterally; dorsomedian portion of anterior margin slightly bulged forwardly though not forming projection in some cocoons; floor woven on posterior 1/2; individual threads usually not visible; 3.0–3.5 mm long by 2.0–2.2 mm wide.

**Mature larva.** Body length 5.0–5.5 mm. Body color whitish-creamy to light ochreous except thoracic segment 1 surrounded by thin light brown band, thoracic segments 2 and 3 broadly light brown on ventral surface, and abdominal segments 1–6 light brown narrowly in form of mediolongitudinal line on ventral surface. Cephalic apotome (Fig. 4A) whitish-yellow to yellow, with dark brown well-defined head spots. Lateral surface of head capsule

Fig. 3. Pupa of *Simulium (Nevermannia) babai* sp. nov. A, frons and part of face of most pupae very sparsely covered with round tubercles and with 3 frontal and 1 facial very long trichomes (right half); B, frons and part of face of different pupa moderately covered with round tubercles (right half; trichomes cut basally); C, face of the same pupa as Fig. B covered with round tubercles only near posterodorsal margin (right side; ventrolateral view); D, gill filaments (left side; outer view); E, basal portion of gill filaments (left side; dorsal view); F, terminal hooks (end view); G and H, cocoon (G, dorsal view; H, lateral view). Scale bars. 0.5 mm for G and H; 0.1 mm for D and E; 0.04 mm for A–C; 0.02 mm for F.



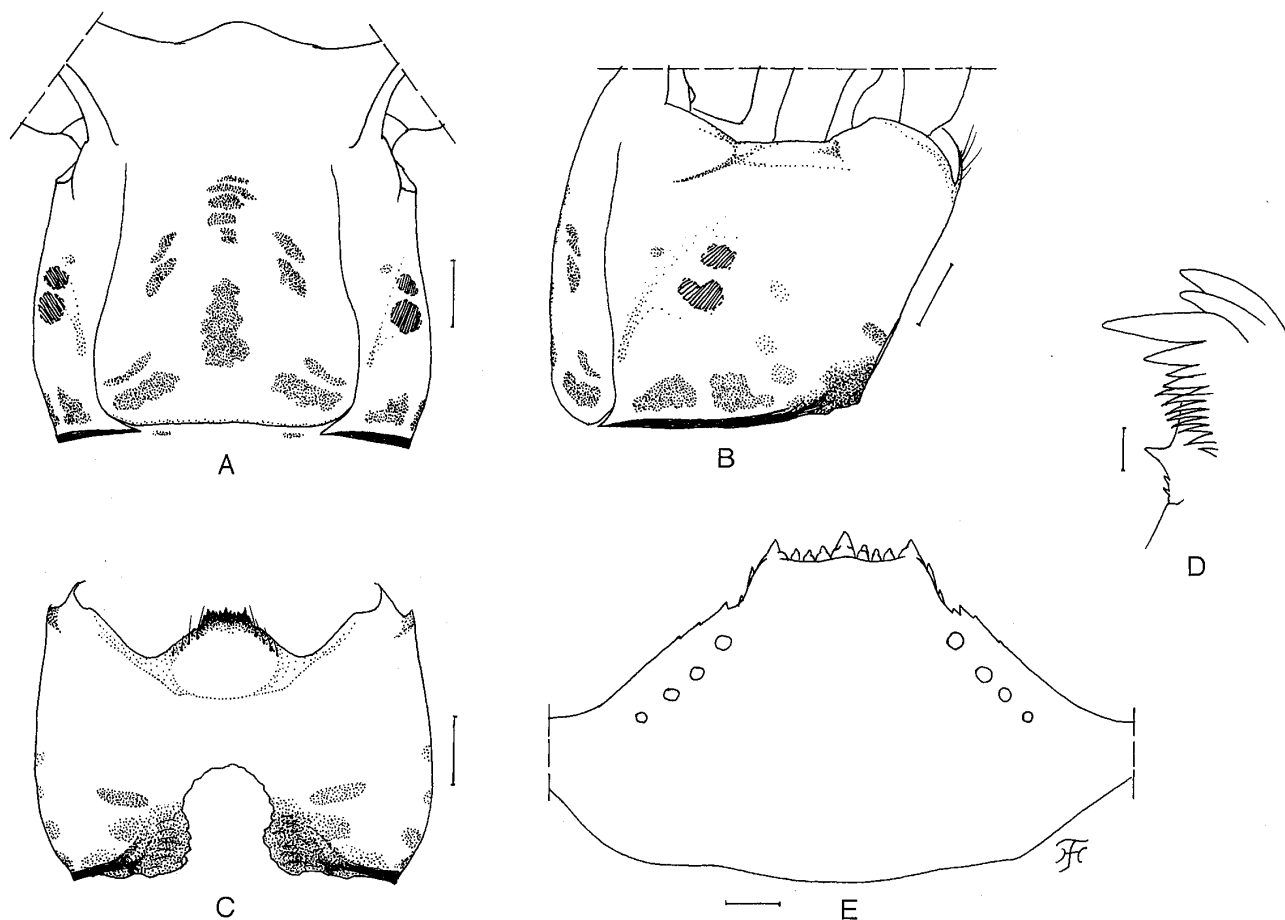


Fig. 4. Mature larva of *Simulium* (*Nevermannia*) *babai* sp. nov. A–C, head capsule (A, dorsal view; B, lateral view; C, ventral view); D, mandible; E, hypostoma. Scale bars. 0.1 mm for A–C; 0.02 mm for E; 0.01 mm for D.

(Fig. 4B) mostly yellow except eye-spot region white; eyebrow faintly-defined, with 1 small medium dark spot; 2 large and 1 small medium to dark brown spots near posterior margin, and 2 small light brown spots below eye-spot region. Ventral surface of head capsule (Fig. 4C) usually yellow, with dark brown area on each side of postgenal cleft, and with dark brown elongate spot and dark brown round spot on each side of postgenal cleft. Cervical sclerites (Fig. 4A) composed of 2 small rod-like pieces, not fused to occiput, widely separated from each other. Antenna composed of 3 segments and apical sensillum, much longer than stem of labral fan, without annular hyaline bands; proportional lengths of 1st, 2nd, and 3rd segments 1.0 : 1.06 : 0.68. Labral fan with 31 rays. Mandible (Fig. 4D) with 1st comb-tooth longest, followed by 3rd one which is longer than 2nd tooth; mandibular serrations composed of 1 large and 2 small teeth, of which 1 small tooth is supernumerary serration; large tooth at obtuse angle to mandible on apical

side. Hypostoma (Fig. 4E) with a row of 9 apical teeth, median tooth and corner teeth prominent; lateral margins weakly serrated near apex or almost smooth; hypostomal bristles 4 in row, parallel to lateral margin on each side. Postgenal cleft (Fig. 4C) medium-long, 1.65 times as long as postgenal bridge, rounded anteriorly; subesophageal ganglion unpigmented, not visible. Thoracic and abdominal cuticle almost bare except dorsal surface of a few posterior abdominal segments sparsely covered with colorless simple short setae and small areas on both sides of anal sclerite moderately covered with colorless simple short setae. Rectal scales darkened, well discernible. Rectal papilla compound, each of 3 lobes with 1 or 2 short thumb-like secondary lobules. Anal sclerite X-shaped, anterior arms 0.8 times as long as posterior ones; accessory sclerites absent; sensillum absent. Ventral papillae well developed, conical in shape. Posterior circlet of hooks with 66 rows of up to 11 hooks per row.



**TYPE SPECIMENS.** Holotype female (reared from pupa) with its associated pupal exuviae and cocoon (preserved in 80% ethanol), collected from a moderately-flowing stream (upper stream of the Okobachi River) (width 0.5–2.0 m, water temperature 12.8°C, shaded, altitude about 100 m), near Okobachi water reserve, Mogami 2-chome, Otaru City, Hokkaido, Japan, 18.VII.2007, by C. Aoki. Paratypes: 5 females, 3 males (all reared from pupae), 2 pupae, and 2 mature larvae, same data as those of the holotype.

**ECOLOGICAL NOTES.** The pupae and larvae of this new species were collected from leaves of grasses trailing in water, together with those of *S. (Boreosimulium) konoii* (Takahasi), *S. (N.) artum* Sato, Takaoka and Saito, *S. (N.) subcostatum* (Takahasi), *S. (N.) uchidai* (Takahasi), *S. (N.) uemotoi* Sato, Takaoka and Fukuda, and *S. (Simulium) japonicum* Matsumura.

**ETYMOLOGY.** The species name *babai* is in honor of Dr. Minoru Baba, Kitakyushu Museum of Natural History and Human History, who greatly contributed to uncovering the ecological aspects of many Japanese species of Simuliidae while he was a staff member in our laboratory from 1983 to 1991.

**REMARKS.** *Simulium (N.) babai* sp. nov. is assigned to the *vernum* species-group within the subgenus *Nevermannia* by having the male ventral plate lamellate, without a median keel (Fig. 2F), style elongate, with a large, broad, inwardly-twisted flange (Fig. 2F, G, I), paramere with a single hook (Fig. 2L), and median sclerite inverted-Y-shaped (Fig. 2F), pupal gill with four slender filaments (Fig. 3D), and larval mandible with supernumerary serration (Fig. 4D).

This new species is very similar to *S. (N.) uemotoi* described from Japan (Sato et al., 2004) in having the yellowish female femora and tibiae, but is distinguished from the latter by the medium-sized senso-

ry vesicle (Fig. 1B) in the female, the smaller number of the male upper eye facets in 12 vertical columns and 15 horizontal rows (cf., in 14 or 15 vertical columns and 16 or 17 horizontal rows in the latter species). In the larval stage, this new species differs from *S. (N.) uemotoi* by the medium-sized postgenal cleft (Fig. 4C).

This new species is also very similar to *S. (N.) subcostatum* described from Hokkaido (Takahasi, 1950) in many characteristics including the medium-sized female sensory vesicle, but is distinguished in the adult by the yellowish femora, the smaller number of the male large eye-facets, and also in the larva by the yellow head capsule with well-defined head spots (Fig. 4A–C).

*Simulium (N.) koshikiense* Takaoka, originally described from Kyushu, Japan, as a subspecies, *S. (N.) subcostatum koshikiense*, by Takaoka (1976), and raised to a full species by Takaoka and Saito (2007a), is very similar in the pupal stage to this new species but is distinguished by having the bare frons (Fig. 5A). The adult of *S. (N.) koshikiense* is also distinguished by having the dark femora and tibiae as well as the large female sensory vesicle (Takaoka, 1976).

#### Supplementary note

During the reexamination of the *vernum* species-group, it became evident that *S. (N.) subcostatum chejuense* Takaoka, described from Cheju Island, Korea (Takaoka, 1974) (type specimens now transferred to and deposited at Department of Infectious Disease Control, Oita University, from Department of Medical Zoology, Kagoshima University) is reliably distinguished from its type subspecies, *S. (N.) subcostatum subcostatum* (Takahasi), by the following characteristics (those of *S. (N.) subcostatum subcostatum* shown in parentheses based on the slide-mounted specimens collected from Hokkaido and identified in 1975 by Dr. H. Takahasi, and also those collected from Hokkaido in

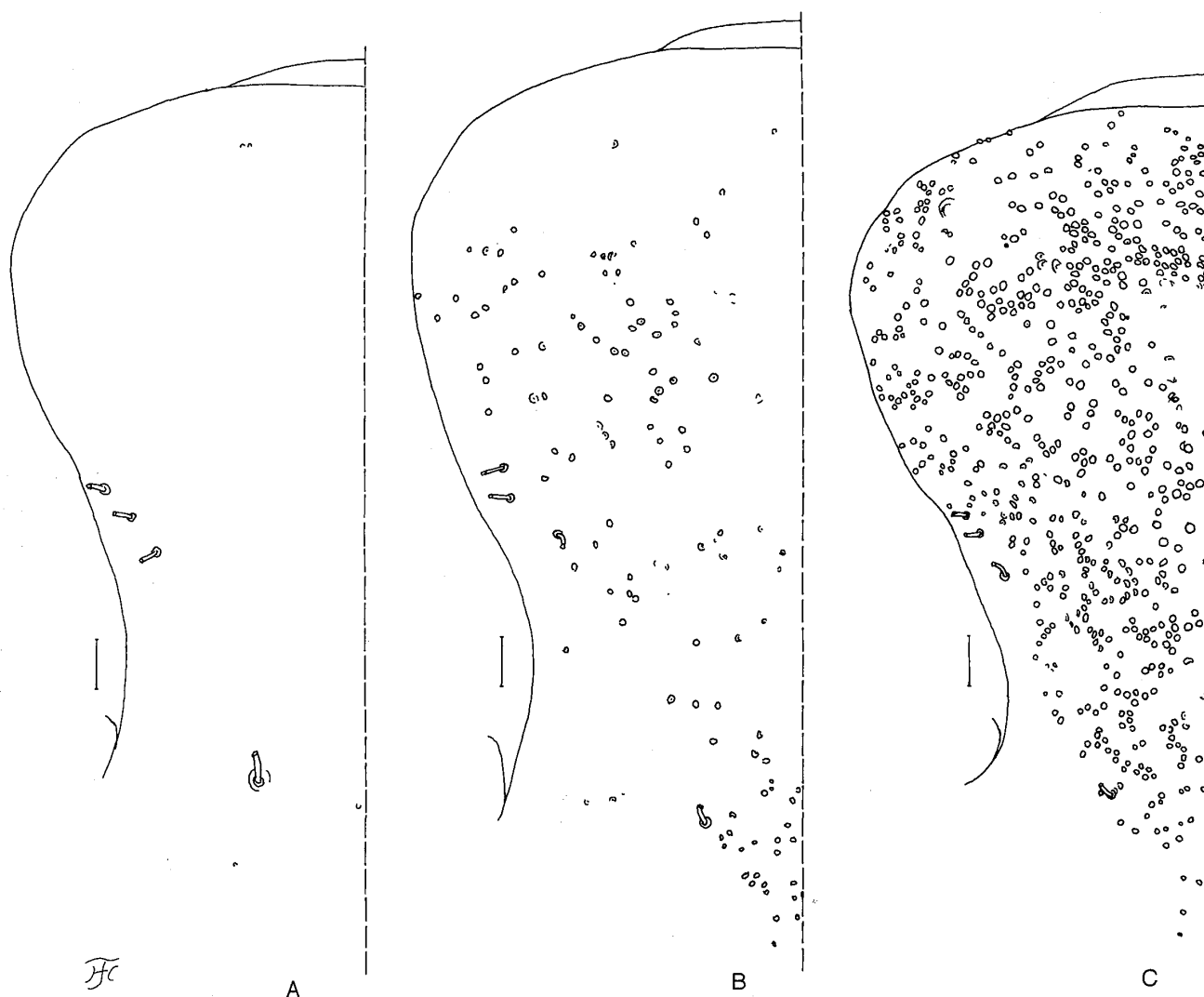


Fig. 5. Pupal frons showing different coverings with tubercles of three taxa of the *vernum* species-group of *Simulium* (*Nevermannia*). A, *S. (N.) koshikiense* Takaoka; B, *S. (N.) subcostatum* (Takahasi); C, *S. (N.) subcostatum chejuense* Takaoka. In all, only right half of frons shown, and trichomes cut basally. Scale bars. 0.04 mm for A–C.

2005 by ourselves; type specimens not located and unavailable): length ratio of the female sensory vesicle against the third maxillary palpal segment 0.61 (0.38), pupal gill filaments always shorter than the pupal body (always longer than the pupal body), pupal gill filaments arising in two pairs almost sessile or with very short stalk from the very short common basal stalk (arising in two pairs with short stalk from the short common basal stalk, similar to those of *S. (N.) babai* sp. nov., Fig. 3 D), and the frontal surface moderately covered with round tubercles (Fig. 5C) (sparsely covered with round tubercles, Fig. 5B). It is here proposed that *S. (N.)*

*subcostatum chejuense* should be treated as a full species, *S. (N.) chejuense* Takaoka, distinct from *S. (N.) subcostatum*.

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